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Long-range spin-singlet proximity effect for a Josephson system with a single-crystal ferromagnet due to its band-structure features

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Abstract

© 2018 American Physical Society. A possible explanation for the long-range proximity effect observed in single-crystalline cobalt nanowires sandwiched between two tungsten superconducting electrodes [Nat. Phys. 6, 389 (2010)NPAHAX1745-247310.1038/nphys1621] is proposed. The theoretical model uses properties of a ferromagnet band structure. Specifically, to connect the exchange field with the momentum of quasiparticles the distinction between the effective masses in majority and minority spin subbands and the Fermi-surface anisotropy are considered. The derived Eilenberger-like equations allowed us to obtain a renormalized exchange interaction that is completely compensated for some crystallographic directions under certain conditions. The proposed theoretical model is compared with previous approaches.

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References

[1] P. G. de Gennes, Rev. Mod. Phys. 36, 225 (1964). RMPHAT 0034-6861 10.1103/RevModPhys.36.225

[2] Y. Izyumov, Y. Proshin, and M. Khusainov, Phys. Usp. 45, 109 (2002). PHUSEY 1063-7869 10.1070/PU2002v045n02ABEH001025

[3] A. I. Buzdin, Rev. Mod. Phys. 77, 935 (2005). RMPHAT 0034-6861 10.1103/RevModPhys.77.935

[4] F. S. Bergeret, A. F. Volkov, and K. B. Efetov, Rev. Mod. Phys. 77, 1321 (2005). RMPHAT 0034-6861 10.1103/RevModPhys.77.1321

[5] R. S. Keizer, S. T. B. Goennenwein, T. M. Klapwijk, G. Miao, G. Xiao, and A. Gupta, Nature (London) 439, 825 (2006). NATUAS 0028-0836 10.1038/nature04499

[6] A. Feofanov, V. Oboznov, V. Bol'ginov, J. Lisenfeld, S. Poletto, V. Ryazanov, A. Rossolenko, M. Khabipov, D. Balashov, A. Zorin, P. Dmitriev, V. Koshelets, and A. Ustinov, Nat. Phys. 6, 593 (2010). NPAHAX 1745-2473 10.1038/nphys1700

[7] M. Eschrig, Phys. Today 64 (1), 43 (2011). PHTOAD 0031-9228 10.1063/1.3541944

[8] M. Blamire and J. Robinson, J. Phys.: Condens. Matter 26, 453201 (2014). JCOMEL 0953-8984 10.1088/0953-8984/26/45/453201

[9] M. Eschrig, Rep. Prog. Phys. 78, 104501 (2015). RPPHAG 0034-4885 10.1088/0034-4885/78/10/104501

[10] J. Linder, M. Cuoco, and A. Sudbø, Phys. Rev. B 81, 174526 (2010). PRBMDO 1098-0121 10.1103/PhysRevB.81.174526

[11] A. Singh, S. Voltan, K. Lahabi, and J. Aarts, Phys. Rev. X 5, 021019 (2015). PRXHAE 2160-3308 10.1103/PhysRevX.5.021019

[12] P. V. Leksin, N. N. Garif'yanov, A. A. Kamashev, Y. V. Fominov, J. Schumann, C. Hess, V. Kataev, B. Büchner, and I. A. Garifullin, Phys. Rev. B 91, 214508 (2015). PRBMDO 1098-0121 10.1103/PhysRevB.91.214508

[13] P. Fulde and R. Ferrell, Phys. Rev. 135, A550 (1964). PRVAAH 0096-8250 10.1103/PhysRev.135.A550

[14] A. Larkin and Y. Ovchinnikov, JETP 47, 1136 (1964).

[15] F. S. Bergeret, A. F. Volkov, and K. B. Efetov, Phys. Rev. Lett. 86, 4096 (2001). PRLTAO 0031-9007 10.1103/PhysRevLett.86.4096

[16] Y. V. Fominov, A. A. Golubov, and M. Y. Kupriyanov, JETP Lett. 77, 510 (2003). JTPLA2 0021-3640 10.1134/1.1591981

[17] M. Houzet and A. I. Buzdin, Phys. Rev. B 76, 060504 (2007). PRBMDO 1098-0121 10.1103/PhysRevB.76.060504

[18] M. Alidoust and J. Linder, Phys. Rev. B 82, 224504 (2010). PRBMDO 1098-0121 10.1103/PhysRevB.82.224504

[19] K. Halterman, O. T. Valls, and C.-T. Wu, Phys. Rev. B 92, 174516 (2015). PRBMDO 1098-0121 10.1103/PhysRevB.92.174516

[20] A. Moor, A. F. Volkov, and K. B. Efetov, Phys. Rev. B 92, 214510 (2015). PRBMDO 1098-0121 10.1103/PhysRevB.92.214510

[21] F. S. Bergeret, A. F. Volkov, and K. B. Efetov, Phys. Rev. B 64, 134506 (2001). PRBMDO 1098-0121 10.1103/PhysRevB.64.134506

[22] Y. V. Fominov, A. A. Golubov, T. Y. Karminskaya, M. Y. Kupriyanov, R. G. Deminov, and L. R. Tagirov, JETP Lett. 91, 308 (2010). JTPLA2 0021-3640 10.1134/S002136401006010X

[23] M. Alidoust and K. Halterman, J. Appl. Phys. 117, 123906 (2015). JAPIAU 0021-8979 10.1063/1.4908287

[24] K. Halterman and M. Alidoust, Phys. Rev. B 94, 064503 (2016). PRBHB7 2469-9950 10.1103/PhysRevB.94.064503

[25] A. I. Buzdin, A. S. Mel'nikov, and N. G. Pugach, Phys. Rev. B 83, 144515 (2011). PRBMDO 1098-0121 10.1103/PhysRevB.83.144515

[26] D. Fritsch and J. F. Annett, Supercond. Sci. Technol. 28, 085015 (2015). SUSTEF 0953-2048 10.1088/0953-2048/28/8/085015

[27] V. Tumanov and Y. Proshin, J. Low Temp. Phys. 185, 460 (2016). JLTPAC 0022-2291 10.1007/s10909-016-16-1-z

[28] A. Cottet and W. Belzig, Phys. Rev. B 72, 180503 (2005). PRBMDO 1098-0121 10.1103/PhysRevB.72.180503

[29] J. Wang, M. Singh, M. Tian, N. Kumar, B. Liu, C. Shi, J. Jain, N. Samarth, T. Mallouk, and M. Chan, Nat. Phys. 6, 389 (2010). NPAHAX 1745-2473 10.1038/nphys1621

[30] F. Konschelle, J. Cayssol, and A. Buzdin, Phys. Rev. B 82, 180509 (2010). PRBMDO 1098-0121 10.1103/PhysRevB.82.180509

[31] G. Eilenberger, Z. Phys. A 214, 195 (1968). ZPAHEX 0939-7922 10.1007/BF01379803

[32] A. Buzdin, L. Bulaevskii, and S. Panyukov, JETP Lett. 35, 178 (1982).

[33] A. S. Mel'nikov, A. V. Samokhvalov, S. M. Kuznetsova, and A. I. Buzdin, Phys. Rev. Lett. 109, 237006 (2012). PRLTAO 0031-9007 10.1103/PhysRevLett.109.237006

[34] A. V. Samokhvalov, A. S. Mel'nikov, and A. I. Buzdin, Phys. Usp. 59, 571 (2016). PHUSEY 1063-7869 10.3367/UFNe.2016.02.037769

[35] F. S. Bergeret and I. V. Tokatly, Phys. Rev. Lett. 110, 117003 (2013). PRLTAO 0031-9007 10.1103/PhysRevLett.110.117003

[36] F. S. Bergeret and I. V. Tokatly, Phys. Rev. B 89, 134517 (2014). PRBMDO 1098-0121 10.1103/PhysRevB.89.134517

[37] A. S. Mel'nikov and A. I. Buzdin, Phys. Rev. Lett. 117, 077001 (2016). PRLTAO 0031-9007 10.1103/PhysRevLett.117.077001

[38] F. Batallan, I. Rosenman, and C. B. Sommers, Phys. Rev. B 11, 545 (1975). PLRBAQ 0556-2805 10.1103/PhysRevB.11.545

[39] S. Monastra, F. Manghi, C. A. Rozzi, C. Arcangeli, E. Wetli, H.-J. Neff, T. Greber, and J. Osterwalder, Phys. Rev. Lett. 88, 236402 (2002). PRLTAO 0031-9007 10.1103/PhysRevLett.88.236402

[40] J. Schäfer, M. Hoinkis, E. Rotenberg, P. Blaha, and R. Claessen, Phys. Rev. B 72, 155115 (2005). PRBMDO 1098-0121 10.1103/PhysRevB.72.155115